Phys 131 2016

Lecture 17

Tues: Discussion / quiz

Supp Ex 45

Ch 7 CQ: 5, 6, 7

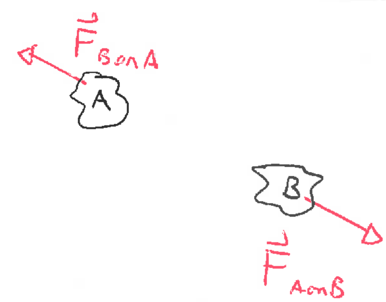
Ch 7 Prob: 9, 29

Newton's Third Law

Newton's third law constrains interactions between objects

If object A exerts a force on object B then:

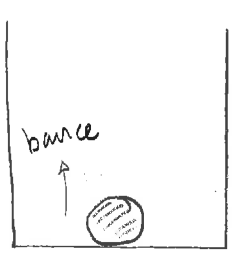
1) B exerts a force on A
2) the forces have equal magnitude and opposite directions

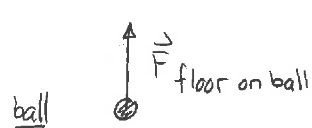


These are an example of an action/reaction pair of forces. Such forces

1) involve only two objects.
2) act on different objects and appear on different FBDs

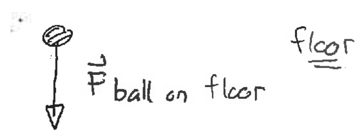
Quiz 1 30% – 50% Σ 40% → 50%





See that

$\vec{F}_{net} \neq 0$



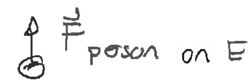
Note that, if we want to assess the motion of one object (e.g. the ball) we only add the forces acting on that object (and not the forces exerted by the ball).

Quiz 2 40% - 50% ; 10% → 60%

Note that although the forces are the same the accelerations that they produce can differ as a result of different masses

person

Earth



$\sum \vec{F} = m_p \vec{a}_{person}$

$\Rightarrow F_G = m_p a_{person}$

$\sum \vec{F} = m_E \vec{a}_E$

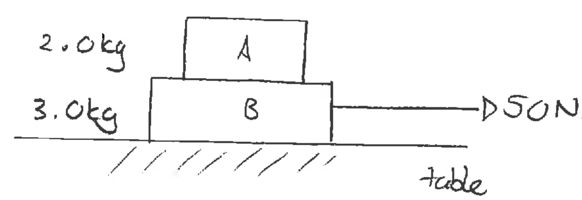
$\Rightarrow F_{P\ on\ E} = m_E a_E$

same.

Larger mass for Earth ⇒ smaller acceleration for Earth

Warm Up! → What would answer be if books were reversed?

Example: Two boxes are stacked; the lower box is on a frictionless table. The lower block is pulled horizontally with a constant force of 50N

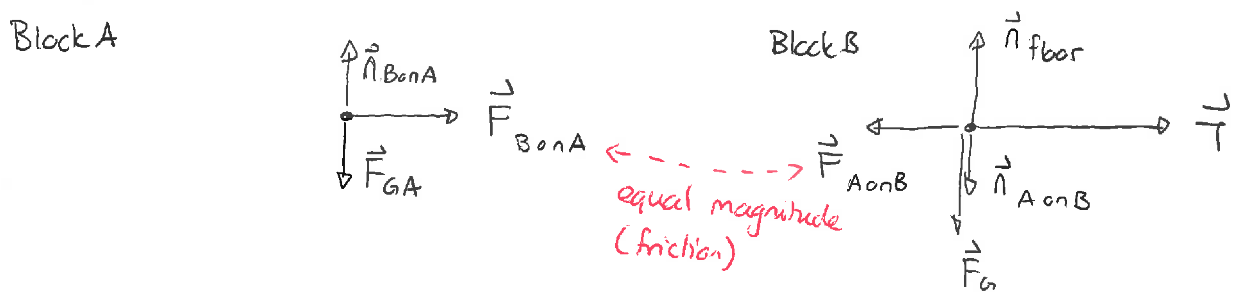


The coefficients of static friction between the blocks is 0.30 and kinetic friction is 0.25. Determine:

a) Whether the upper block slips.

b) The acceleration of both blocks

Answer: In either case we need the FBDs for both:



a) If the blocks do not slip then $\vec{F}_{B on A}$ is static friction. Let $\vec{a}_A$ be the acceleration of A. Then

$$\sum_{on\,A} F_x = m_A a_{Ax} \Rightarrow F_{B on A} = m_A a_{Ax}$$

$$\Rightarrow F_{B on A} = 2.0\,\text{kg}\; a_{Ax}.$$

But if the blocks don't slip then they move together. Analyzing them as one object gives: $\sum F_x = M_{both}\, a_x \Rightarrow 50\text{N} = 5.0\,\text{kg}\; a_x$

$$\Rightarrow a_x = 10\,\text{m/s}^2.$$

Thus if the blocks do not slip then $F_{B on A} = 2.0\,\text{kg} \times 10\,\text{m/s}^2 = 20\text{N}$.

This is a friction force and the maximum friction force is

$$f_{s\,max} = \mu_s n_{B on A} = \mu_s F_{GA} = \mu_s m_A g = 0.30 \times 2.0\,\text{kg} \times 9.8\,\text{m/s}^2$$
$$= 5.9\text{N}$$

This is less than the force needed to prevent A from slipping. Thus A slips.

b) Since A slips $\vec{F}_{B on A}$ is kinetic friction and

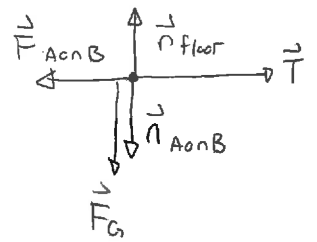
$$F_{B on A} = \mu_k n_{B on A} = \mu_k m_A g = 0.25 \times 2.0\,\text{kg} \times 9.8\,\text{m/s}^2 = 4.9\text{N}$$

Thus for A: $\sum_{on\,A} F_x = m_A a_{Ax} \Rightarrow F_{B on A} = m_A a_{Ax}$

$$\Rightarrow 4.9\text{N} = 2.0\,\text{kg} \times a_{Ax}$$

$$\Rightarrow \boxed{a_{Ax} = 2.5\,\text{m/s}^2}$$

Now consider B



$\sum F_x = m_B a_{Bx}$ ← Newtons 2nd Law

$\Rightarrow \quad T - F_{AonB} = m_B a_{Bx}$

But $\quad F_{AonB} = F_{BonA} = 4.9N$. ← Newtons 3rd Law

Thus

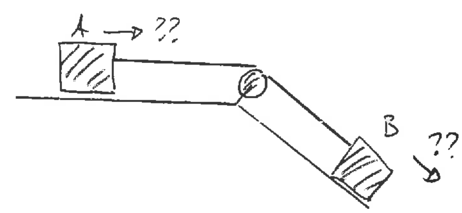
$$50N - 4.9N = 3.0kg \; a_{Bx}$$

$$\Rightarrow \quad 45N = 3.0kg \; a_{Bx}$$

$$\Rightarrow \quad \boxed{a_{Bx} = 15 m/s^2}$$

Objects connected by ropes/cables...

In various physics situations two objects are connected by a rope which is taut but whose length does not change. In such situations, there are three interacting objects



- object A
- object B
- rope.

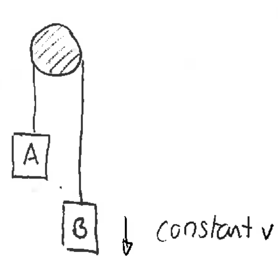
Newton's 2nd and 3rd Laws show

see pg 170

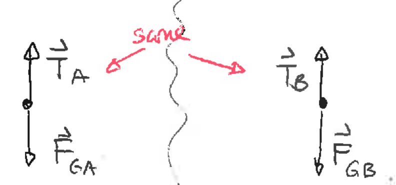
> If the rope is massless then the force exerted at any point along the rope is the same as that at any other point. Thus the tension is the same throughout.

Note that if the rope runs over a pulley with mass then this effectively "attaches" mass to the rope.

Warm Up 2



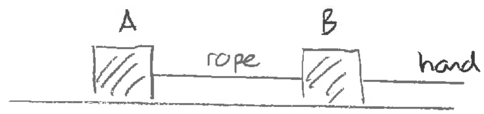
On A | on B



$\vec{F}_{net\,A} = m_A \vec{a}_A = 0$ $\quad$ $\vec{F}_{net\,B} = m_B \vec{a}_B = 0$

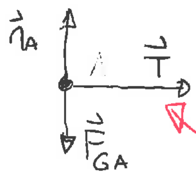
$\Rightarrow T_A = m_A g$ $\quad$ $T_B = m_B g$ $\quad$ same m $\Rightarrow$ same T.

We can now address problems with objects connected by ropes

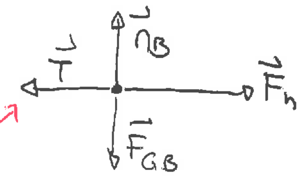


Do Newton's 2^{nd} Law for each

① FBD for A



FBD for B



Same Tension
(Newton's Third Law)

② $\sum_{\text{on } A} F_x = m_A a_{Ax}$ $\qquad$ $\sum_{\text{on } B} F_x = m_B a_{Bx}$

③ Components

④ Objects move together $\quad a_{Ax} = a_{Bx} \equiv a$